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## **Instrumentation for the Testing of Friction & Wear under Very High Electromagnetic Stress DURIP Grant N00014-05-1-0499**

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To enhance the quality and scope of experiments proposed under an FY04 DoD MURI grant concerning the friction and wear of surfaces subjected to very high electromagnetic stress, a total of **\$398,941.33** was spent for test instrumentation acquired through funds awarded to Georgia Tech by FY05 DURIP Grant N00014-05-1-0499. Included in the purchase was i) a high-speed linear tribological test unit and pulse-discharge power supply for \$372,411; and ii) a data acquisition suite, comprised of a \$50K strain recording instrument (partially funded by the DURIP grant at \$10,875) and assorted material components valued at \$15,655.33.

Installation and purchase of the high-speed linear tribological test unit or lab-scale railgun was completed in January 2006. Designed and manufactured by IAP Research (Dayton, OH), the containment of this instrument as shown in Fig. 1, is constructed with stainless steel laminations and the upper and lower halves are clamped together with high strength steel bolts. It is rated for a peak operating current of 500 kA and has a nominal length of 1.5 m. Upon its commissioning, the core of the device was constructed with chrome copper rails (CDA 182) and G-10 glass composite insulators. The bore configuration was 12.5 mm square, and the shot travel distance was ~155 cm. A capacitor bank power supply was also commissioned during these tests and is shown in Fig. 2. This capacitor bank consists of six (6) independently triggerable submodules, which each can store 16.7 kJ at 5.7 kV, and therefore has a total stored energy of 100 kJ at 5.7kV. Each module is rated for a peak current of 100 kA. The power supply provides current to the railgun via six 350MCM size, 3m long coaxial cables.

To conduct accurate, safe and useful tribological experiments, control and data gathering instrumentation was developed as shown in Fig. 3a. The assembled componentry, designed as a data acquisition suite with data storage and video capture, evolved throughout calendar year 2006 as sensor output was analyzed from initial railgun firings. To satisfy test requirements, the strain recording instrument of Fig. 3b was developed by Micron Optics, Inc. (Atlanta, GA) and added to the data acquisition suite in January 2007. The device has a strain range of  $\pm 5000$   $\mu\epsilon$  with a sampling rate of 500 kHz on one channel or 200 kHz on four simultaneous channels.

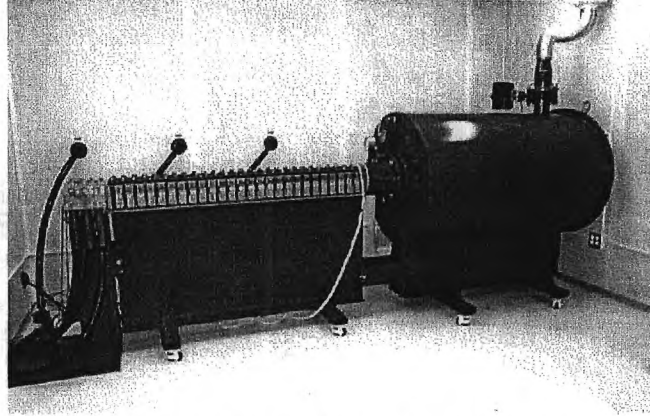
### **Statement of Current and Future Use**

Each of the items identified above and purchased through the DURIP grant have been integrated to provide an experimental system capable of gathering reliable data for use in controlling the friction and wear that accompanies railgun firing. It is currently being used to support a DoD MURI grant, tentatively scheduled to conclude in April 2009. It is anticipated that the equipment will function without major maintenance beyond its minimum design life of ten years.

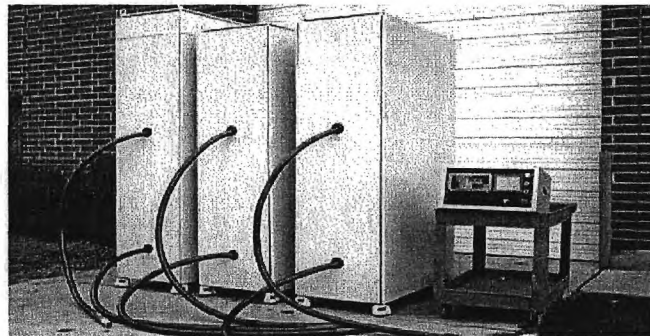
The instrumentation is housed in a 900 sq. ft. laboratory, built through internal funds and designed to serve as a place to provide students with the opportunity to experience how textbook concepts can be applied through demonstration. Relevant courses include i) the graduate course *Fluid Film Lubrication*, which includes the concepts of concentrated contact, elasticity, and the mechanics of rough surfaces; ii) the graduate course *Contact Mechanics*, covering thermo-electrical effects in sliding contact; iii) the design course *Tribological Design*, an undergraduate elective promoting the concepts of surface engineering; and iv) the undergraduate course *Fluid Mechanics*.

It is intended that the equipment be used for other projects of tribological interest as they are identified. This particular system, though it involves technology that the U.S. Navy and Army would like

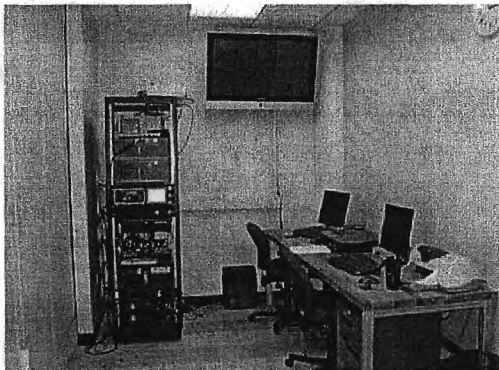
to have, can be used not only for weapons, but also in electromagnetic launchers for satellites or the sliding of maglev vehicles. It also has relevance to the thermal management study of electrical systems, an item of increasing interest to the DoD as cooling hardware approaches a size that cannot be accommodated on anticipated vehicle platforms.



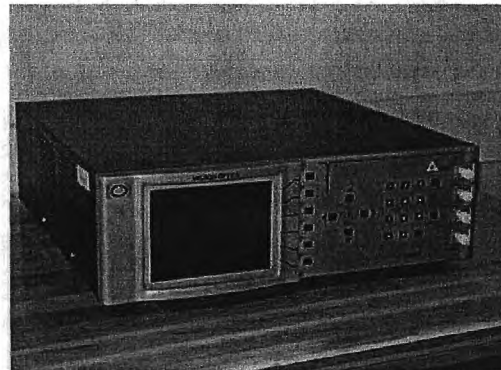
**Figure 1.** High-speed linear tribological test unit (lab-scale railgun)



**Figure 2.** Configuration of six-module capacitor bank power supply



(a)



(b)

**Figure 3.** Data acquisition suite with a) computer componentry and b) strain instrument.

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## Deliverable Summary

**Doc ID:** 99345**PS Project #:** 12966D3**PS Fund #:** R6118**Old Project #:** B-01-6D3**Project Title:** DURIP/ INSTRUMENTATION FOR THE TESTING OF FRICTION & WEAR UNDER VERY HIGH**PD/PI(s):** DANYLUK, STEVEN (PDPI)/COWAN, RICHARD S (COPDPI)/BAIR, SCOTT S (COPDPI)/STREATOR, JEFFREY L (COPDI)**Sponsor:** NAVY/OFC OF NAVAL RESEARCH**Unit/Lab:** MARC**Deliv ID:** 1**Due Date:** 31-JAN-2007**Number of Copies:** 0**Deliverable Title:** FIN EQUIP LIST/PERF REPORT**Period Covered:** 01-MAY-2005 through 31-OCT-2006**WebWISE Status:** Submitted to OSP**WebWise Mailed Date:** 05-Feb-2007**Status Changed By:** COWAN,RICHARD**Status Changed Date:** 05-FEB-2007**WebWISE Status:** Submitted to OSP**WebWise Mailed Date:** 05-Feb-2007**Status Changed By:** COWAN,RICHARD**Status Changed Date:** 05-FEB-2007**Details Sent to OSP/OCA:****Will PD send a paper copy of the deliverable to OSP (no upload):** N**Is Deliverable Classified:** N**Is Deliverable Restricted:** N**Does OSP need to send the deliverable to sponsor:** Y**Comments to OSP:** The deliverable, attached, was e-mailed to the ONR Atlanta office by GTRI Kathleen Falconer on 2/1/07.**Attachment List:**[FY05 DURIP ONR project.pdf](#)**Research Report Approval Sheet:**[\[View Research Approval Sheet\]](#)**Email notification details:****Complete Details Sent from:** rick.cowan@me.gatech.edu**Complete Details Sent to:** ocareports@osp.gatech.edu, steven.danyluk@marc.gatech.edu, rick.cowan@me.gatech.edu, Kathleen.Falconer@gtri.gatech.edu**Sponsor Notified with deliverables attached:** N

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